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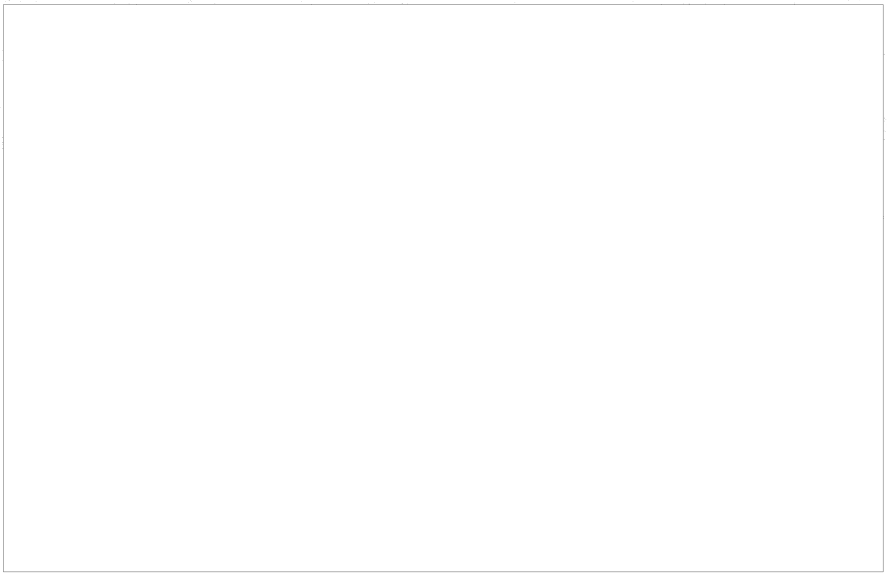

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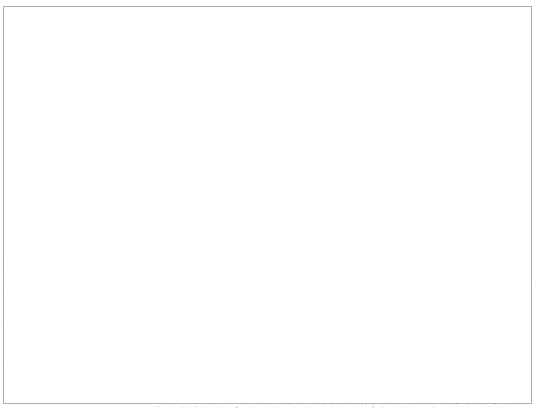
Factors Influencing the Variability of Annual Drainage (Run-Off)

Meteorologiya i Gidrologiya, D. L. Sokolovskiy
Moscow, April 1948



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FACTORS INFLUENCING THE VARIABILITY OF ANNUAL DRAINAGE (RUN-OFF)

D. L. Sokolovskiy

[Note: The following article appeared in the 'Criticism and Bibliography' section of Meteorologiya i Gidrologiya No. 4 (1948), pages 91-2.]

In recent hydrological literature there has again emerged the problem of factors influencing the magnitude of variability of annual drainage, and particularly the effect upon it of reservoir* size. Thus, for example, V. D. Zaykov (3) constructs a chart of isolines of the variation coefficient of annual drainage for Caucasian territory without emphasizing the area factor, since, in his opinion ". . . the analysis of available data indicates that for Caucasian rivers having a watershed area up to 3500-4000 square kilometers, the immediate effect of watershed area upon the variation coefficient is negligible and can be ignored for practical purposes." *[Note: This word "reservoir" can be replaced by "basin".]

A. I. Chebotarev also constructed a chart of isolines of the variation coefficient of the DVK* territory, indicating that " . . . the lack of clearly defined relationship between the variation coefficient and watershed dimensions of DVK rivers may be explained by the weak natural ~~regulating~~ regulating ability of river watersheds of this region, as expressed by negligible topsoil water supply." *[Note: "DVK" stands for Dal'niy Vostochnyy Kray, which means "Far East Region".]

A more definite pronouncement is made by L. K. Davydov. Analyzing the existing formulas for C_v, L. K. Davydov notes that " . . . up to the present time there is nearly a complete lack of clearly formulated basic theses* on the relationship between C_v and influencing factors, and, what is more important, no disclosure is made on the nature of these relationships. *[Note: "Theses" can be replaced by "assumptions", or "positions".]

"All of the attempts made in this direction are of a somewhat exclusively empirical nature and boil down to the establishment of conjectural relationships between C_v and influencing factors."

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Desirous of establishing the relationship between C_y and influencing factors, L. K. Davydov, using the equation of aqueous [water] balance $y = x - z_0$, where [illegible], and the general regression equation of 3 variables, arrives at the conclusion that:

$$C_{v_y} = \frac{1}{n} C_{v_x} \cdot A \qquad (1)$$

Where C_{v_x} is the variational coefficient of precipitation, n is the drainage coefficient, and

$$A = \sqrt{\frac{1 - r_{xz_0}^2}{1 - r_{yz_0}^2}} \,. \qquad (2)$$

"Therefore, the variational coefficient of annual drainage depends primarily on the variational coefficient of precipitation and drainage coefficient. [Note: "drainage" and "run-off" can be interchanged.]

Naturally, on the basis of equation (1), we cannot talk about any interconnection between the variational coefficient and watershed area.

This conclusion by L. K. Davydov contradicts experimental data, as well as other lorical considerations.

Therefore, we shall attempt to clarify the mechanism of watershed area influence upon the variability of annual drainage.

Numerous persons, including N. D. Antonov (2), have expressed the opinion that the basic reason for the influence of watershed area upon the variability of annual drainage is due to the fact that the watershed acts as an integrator of distinct special phenomena; this integrator levels off the individual physico-geographical conditions of its separate portions, and therefore smoothes the amplitude

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of drainage variation in its component parts. However, the influence of watershed area upon the variability of annual drainage does not stop here.

The variability of annual drainage is obviously dependent, in the first place, on the natural regularity of reservoir drainage, i.e. on the availability of surface (lakes) and subterranean (subsoil moisture reserves) drainage regulators.

It is known that the availability of lakes in the watershed greatly reduces the variability of annual drainage. Such an effect is also caused by the subterranean water reservoirs in the form of subsoil moisture reserves. Mainly due to this there is an increase in the variation coefficient of annual drainage of rivers in dry regions, and not only as a result of increased precipitation variability (small, to be sure) and decrease in drainage coefficient. Volume of the subsoil water reservoir increases proportionally to the third power of linear dimensions, i.e. faster than the watershed area.

However, to a first approximation, and in the absence of data on volume of subsoil water reservoir in regions of adequate moisture content, the watershed area can be taken as an indirect indicator of the volume of the subsoil reservoir, and, consequently, as an indicator of natural drainage regularity.

In dry regions, such as, for example, in Kazakhstan, where subsoil water supply for rivers is almost non-existent, watershed area ceases to influence the variability of annual drainage (although it would seem that it should influence it, being the drainage integrator for the entire watershed). Snow disappearance conditions come into play in Eastern Siberia and DVK, where the near location of perennial ice determines the negligible subsoil water supply of rivers, and

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therefore the effect of the watershed area here is less than that over the territory of European USSR. This permitted A. I. Chebotarev to construct a chart of isolines of the variation coefficient of annual drainage without considering the area factor.

Finally, in mountain regions where the gradient of variation of climatic factors is very great, climatic effects predominate over the area factor (which is expressed in the majority of formulas by a multiplying factor in the order of 0.06 of log F); and, therefore, within practical accuracy it is possible to construct a chart of isolines of the variation coefficient of annual drainage, without considering the area factor; this was done by B.D. Zaykov for Caucasian territory.

Thus it must be acknowledged that undoubtedly the effect of area factor upon the variability of annual drainage is not disclosed by the formal mathematical analysis of L. K. Davydov; partially, however, this phenomenon, although not recognized by him, is taken care of by formula (1).

Actually, by C_{v_y} in formula (1) is meant the coefficient of precipitative variation for the entire watershed $C_{v_x}(F)$, which becomes smaller for the individual meteorological station as F increases.

Besides, L. K. Davydov's analysis did not disclose the effect, upon variability of annual drainage, of the basic component of the aqueous-balance equation; this component by and large determines the variability of annual drainage, specifically of the variations in subsoil moisture reserves, expressed by the term $\pm\Delta u$ which includes evaporation.

Thus, we must draw the following conclusions:

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1. that besides climatic factors, the variability of annual drainage is influenced by other physico-geographical factors, the basis of which is the watershed area; and in the case of rivers flowing from lakes -- the number of lakes.

This is well expressed in my first (in a series of analogous formulas) formula of 1930: $C_v = a - a_1 \log(F)$, where the parameter a reflects the effect of climatic factors and $f(F)$ -- the effect of area factor.

2. that the watershed area acts not only as a statistical integrator of distinct local phenomena but also as a physical indicator of the drainage-regulating volume of the subsoil water reservoir.

3. that in those regions where the subsoil moisture reserves are negligible, or altogether non-existent (as in Central Kazakhstan, or in perennial ice regions), watershed area ceases to have a regulating effect upon the variability of annual drainage.

In mountain regions the sharply variable climatic factors undoubtedly blot out the area factor effect upon the variability of annual drainage.

4. that L. K. Davydov's analysis disclosed the mechanism of the effect of climatic factors upon the variability of annual drainage; however, it did not disclose the nature of the relationship between C_v and other physico-geographical factors, in particular the watershed area, which reflects approximately the degree of natural regulation of annual drainage by the subsoil moisture reserves.

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